General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

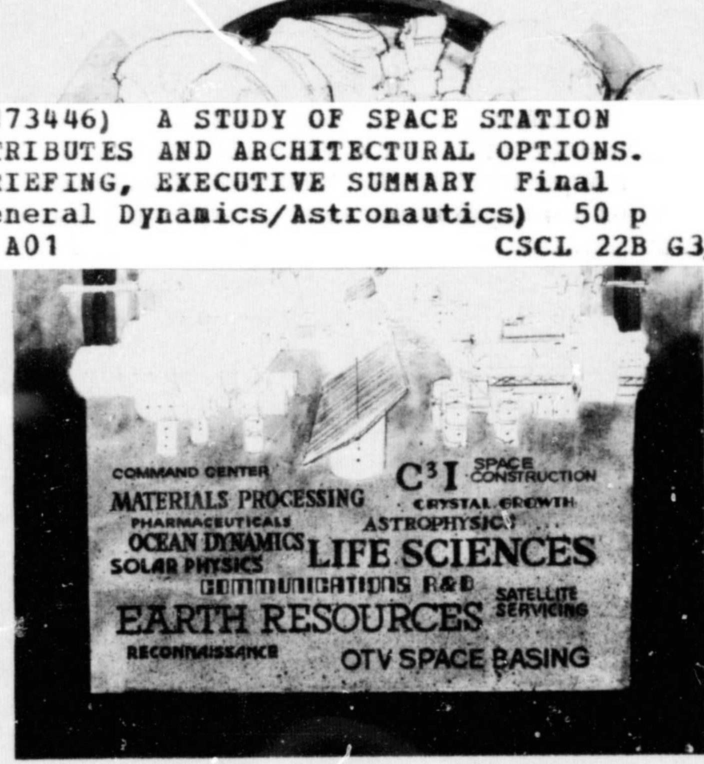
Produced by the NASA Center for Aerospace Information (CASI)

A STUDY OF SPACE STATION NEEDS, ATTRIBUTES & ARCHITECTURAL OPTIONS

Midterm Briefing

Executive Summary

(NASA-CR-173446) A STUDY OF SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS. MIDTERM BRIEFING, EXECUTIVE SUMMARY Final Report (General Dynamics/Astronautics) 50 p HC A03/MF A01 CSCL 22B G3/18
N84-27808
Unclas
00853



RECEIVED JUL 1984

GENERAL DYNAMICS

Convair Division

Contract No. NASW 3682

A STUDY OF SPACE STATION NEEDS, ATTRIBUTES & ARCHITECTURAL OPTIONS

Midterm Briefing

Executive Summary

14 December 1982

Presented to
National Aeronautics and
Space Administration

GENERAL DYNAMICS
Convair Division

AGENDA

- Study Plan/Approach
- Major Study Conclusions
- Commerical Applications
- Evolutionary Options

A major focus during the first phase of our study was directed towards the development of a broad Space Station interest within the commercial and DoD communities. It was also our objective to identify areas of maximum benefit from a Space Station and initiate detailed analysis activities to accurately quantify the associated economic benefits.

SPECIFIC FOCUS OF GENERAL DYNAMICS STUDY
Initial Study Phase

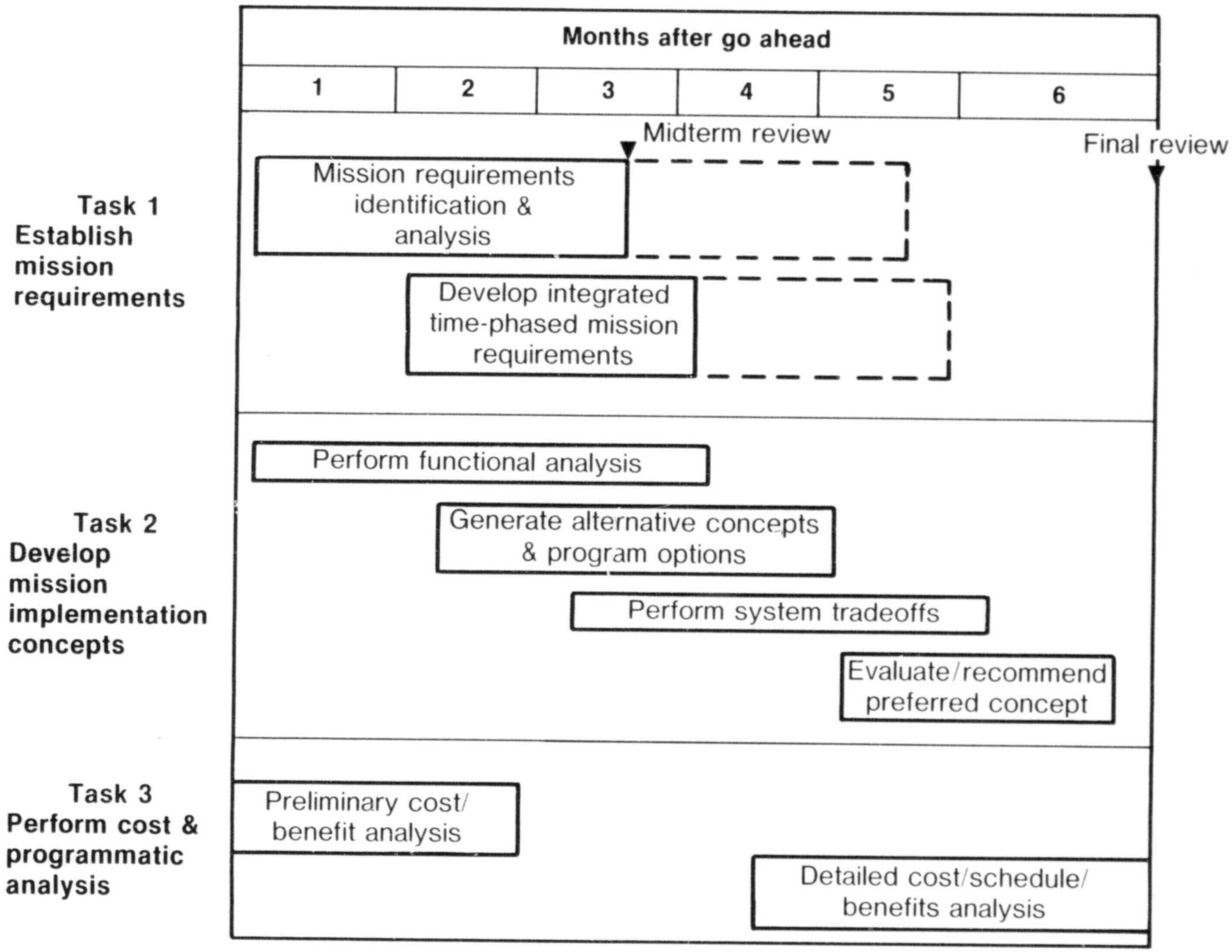
- Concentrate on development of a broad spectrum of user involvement — particularly in the commercial area
- Develop operational DoD mission scenarios based on functional needs & review/iterate with broad DoD community
- Carry out mission requirements analysis independent of architectural, cost, or programmatic considerations
- Identify areas of maximum benefit from a space station & initiate in-depth analysis
- Formulate requirements into a data base appropriate for defining candidate architectural concepts, evolutionary strategies & related costs

Our study activities during the first phase closely followed the detailed study plan submitted to NASA. Task completion is essentially on schedule. The task of identification and analysis of mission requirements is largely complete; continued iterations with users, however, will take place. Development of time phased requirements is well underway and will be completed within the next month.

Preliminary evolutionary concepts to be evaluated in the next phase have been defined.

Initial cost and benefit analysis to support activities underway in the mission requirements and implementation concepts areas have been carried out.

STUDY PLAN



15112/93-26

The approach to identification and collection of mission requirements is shown on the facing page for typical discipline areas. A "User Brochure" was used for initial contact with a very broad commercial user community. Extensive contacts (104) were made with NASA or University research personnel in the Life Science area. A data exchange agreement has been signed with ERNO representing the Spacelab consortium. National security requirements have been obtained from a DoD provided data base, and through extensive discussions with DoD personnel. Contacts have been made with communication spacecraft users, owners and operators. The NASA provided data base for the Science and Application area has been augmented by extensive discussions with involved personnel, and by an earlier established General Dynamics data base.

STUDY APPROACH
Step 1 — Identify/Collect Mission Requirements (Examples)

Commercial
- 155 commercial firms contacted
- 182 brochures mailed
- Data exchange in progress
- Telecons/meetings held
- Detailed discussions in progress

Life science
- 104 contacts established
- Advanced Technology, Inc subcontract
- American Physiological Society
- Data exchange in progress
- Discussion/meetings held

Foreign
- Data package from ERNO (spacelab consortium)
- Working session with ERNO planned early January
- Support from SPAR in January 1983
- AEG, Dornier, IHI, AIT discussions held

National security
- DoD data base
- Meetings with SAC, TAC, SD Detachment (JSC)
- SAI subcontract
- Detailed follow-up discussions planned

Communication satellite industry
- SPACECOM subcontract
- Discussions with American Satellite, COMSAT General, Fairchild, SBS, Western Union, American Telecon

Astrophysics
- NASA data base
- Discussions MSFC, Los Alamos National Lab
- Shuttle payload definition studies

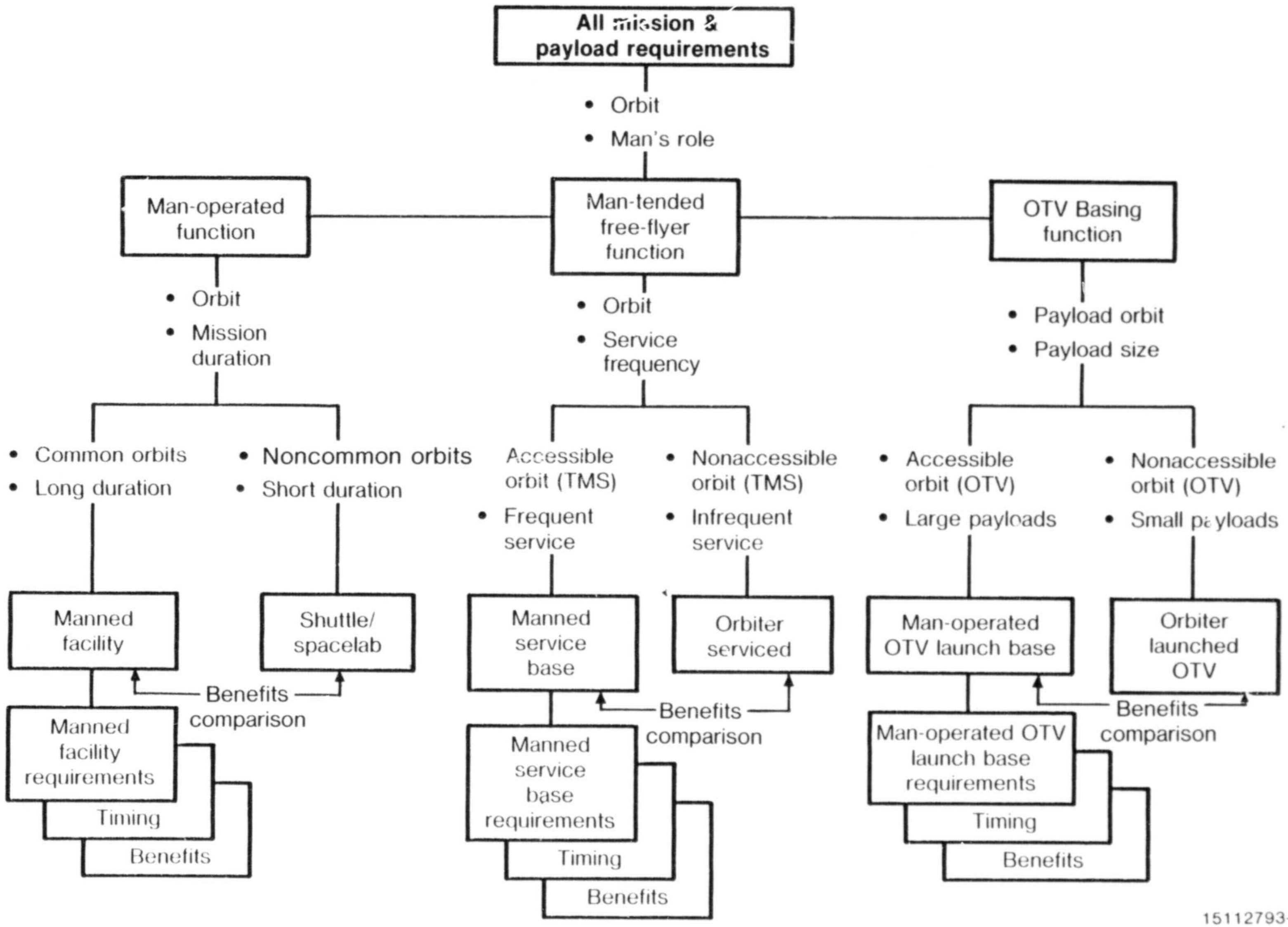
All mission & payload requirements

15112893-27A

The total requirements which were collected were divided into three major functions (man-operated, man-tended, and OTV basing) using orbit requirements and man's potential role in the mission as the principal criteria for categorization. These requirements were then further subdivided into functions which would significantly benefit from a permanent presence in space (manned facility, manned service base, or man operated OTV launch base) or which could be satisfactorily performed with the existing Shuttle/Spacelab capability.

Requirements for the manned facility, manned service base, and man-operated OTV launch base were then defined and timelined. Performance and economic benefits which accrued in each area were also defined.

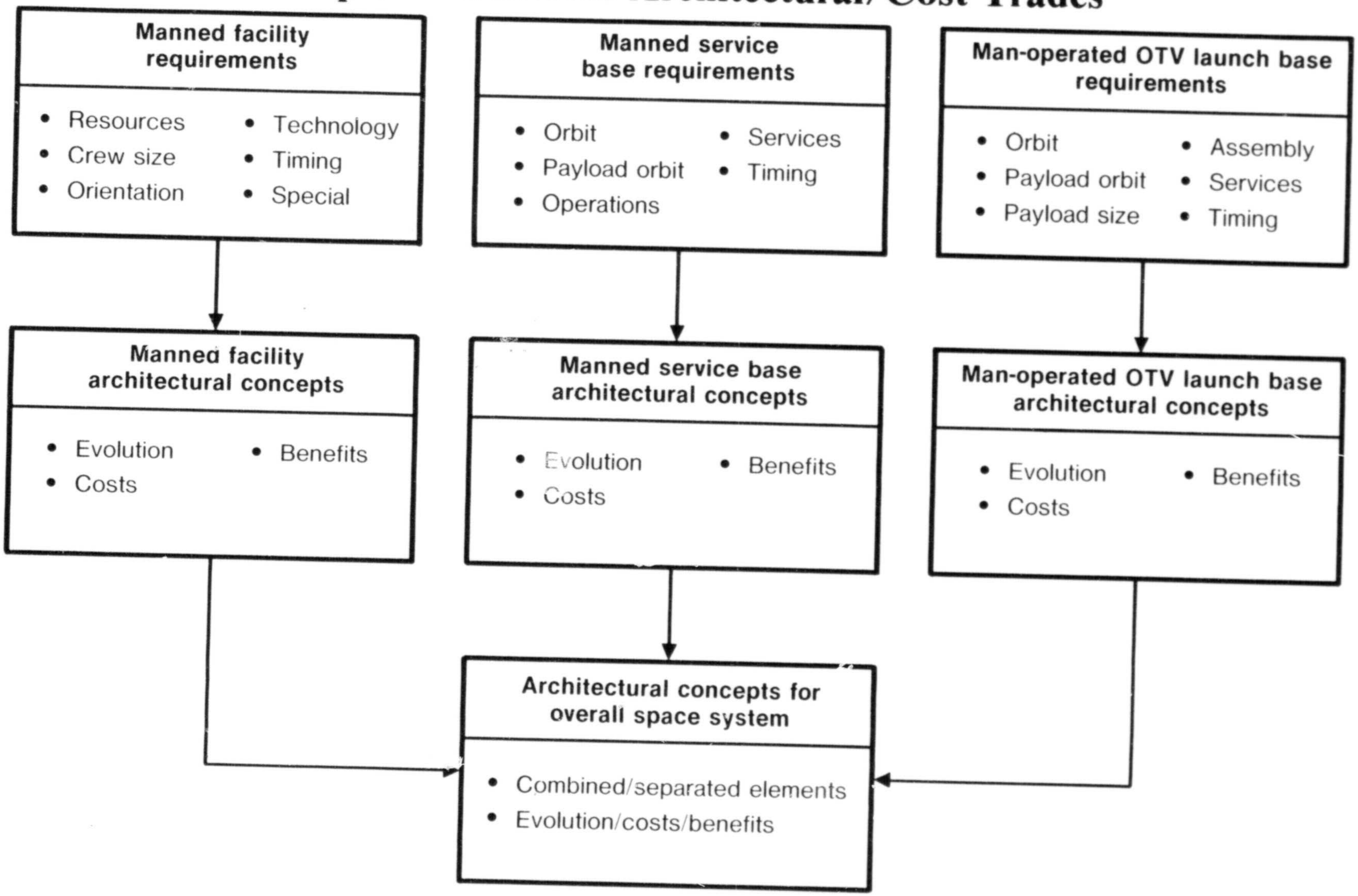
STUDY APPROACH (continued)
Step 2 — Characterize Requirements



15112793-28A

This task, which involves identification of appropriate Space Station architectural concepts and program evolutionary strategies, will be largely carried out in the second phase of our study. Architectural concepts for each of the 3 elements of the system will be defined based on requirements which have been accumulated, considering various parameters such as orbit, crew, and orientation requirements, and the level of resources (power, etc.) which must be provided to support the mission. The three system elements will then be assessed from the standpoint of whether separate or combined elements offer the greatest economic and/or performance benefits.

STUDY APPROACH (continued)
Step 3 — Perform Architectural/Cost Trades



15112793-29

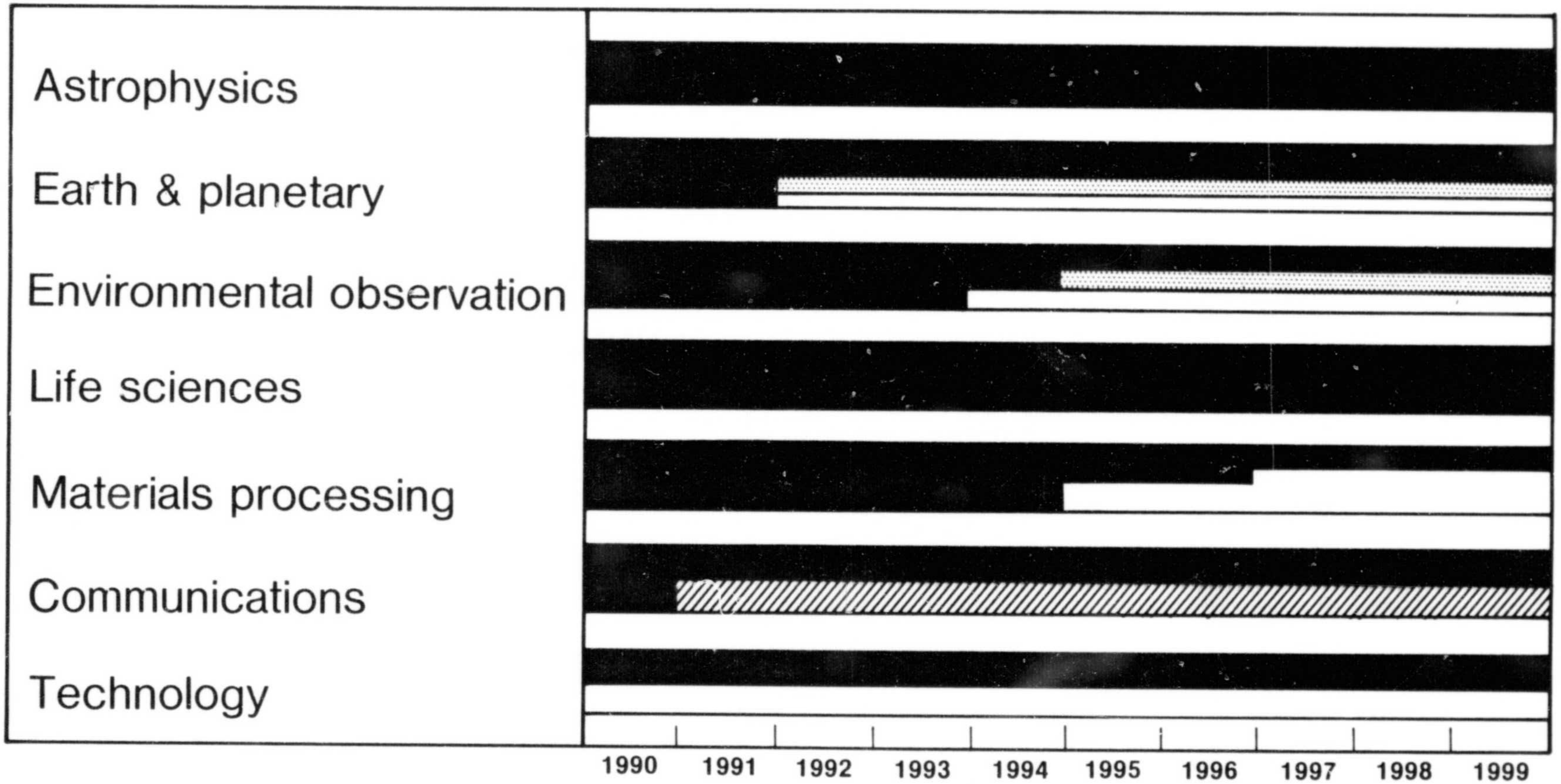
Although all mission objectives were derived from NASA sources, the technical data, i.e. power, crew, data, etc., for the individual missions have various pedigrees. Some of the data has direct traceability to a NASA document and others are the result of internal GDC extrapolation. The degree of traceability varies between disciplines. The width of the bars in the figure indicates the approximate percentage of mission data within the following categories:

1. Data from NASA documentation or NASA contract study reports.
2. Data from users other than NASA, for example, universities.
3. Data generated by GDC extrapolations based upon other reports or technical knowledge and then confirmed by discussion with outside sources, i.e. potential users.
4. Data generated by GDC extrapolations based upon other reports or technical knowledge.

The Astrophysics and Life Sciences Mission Data are all traceable. A major share of the Earth and Planetary, Environmental Observations, and Materials Processing Missions are also traceable to NASA documents as is the Communications Traffic Model. The Communication Experiments were derived internally (in this case, by a subcontractor) and discussed with commercial communication satellite firms. Technology mission requirements were defined in qualitative terms in NASA documentation and were transformed into quantitative terms by GDC. They are therefore defined as half-and-half traceable and extrapolated.

MISSION REQUIREMENTS DATA MATURITY

ORIGINAL PAGE IS
OF POOR QUALITY



- Data from NASA documentation & contract reports
- Data from users (eg, universities)
- Extrapolations by General Dynamics Convair — confirmed by outside sources*
- Extrapolations by General Dynamics Convair*

* All mission objectives derived from NASA or user sources

15112793-201

AGENDA

Study Plan/Approach

Major Study Conclusions

Commerical Applications

Evolutionary Options

PRECEDING PAGE BLANK NOT FILMED

PAGE 14 INTENTIONALLY BLANK

MAJOR STUDY CONCLUSIONS

PRECEDING PAGE BLANK NOT FILMED

A space station will provide major performance benefits to a wide range of missions planned for the 1990s

PAGE 16 INTENTIONALLY BLANK

Major benefits are indicated that are directly attributable to having man in orbit for extended time periods for the conduct of research, and for development of advanced technologies. These benefits will be realized in both low "g" research, and viewing Communications and Technology experiments missions.

Man's tending of free-flyers, either from a Shuttle or from space-based systems, provides benefits in quality of observations, and in extending the useful life of observatories.

Benefits of a performance nature resulting from OTV basing are primarily due to man's capabilities for on-orbit checkout and servicing of spacecraft prior to commitment to HEO and GEO missions. At later dates additional benefits may accrue from servicing of GEO spacecraft by man at LEO or by automated means at GEO.

SUMMARY OF PERFORMANCE BENEFITS

Function	Potential Benefit	Disciplines/Missions
Man-operated (82 missions)	• Scientific research requiring man's presence for periods exceeding 12 to 14 days	Life Sciences
	• Advanced technology development requiring man's presence over extended mission times	Communications Earth/planetary Env observations Materials processing
	• Assembly and servicing of large observatories in LEO	Astrophysics
Man-tended free flyers (18 missions)	• Increased quality of observations by on-orbit servicing of sensors & spacecraft	Astrophysics Envir observations
	• Increased useful life of observatories by update/changeout of sensors, replenish consumables	Astrophysics
OTV basing (46 missions)	• Increased quality & reliability of spacecraft systems by checkout, servicing and deployment, prior to commitment to GEO	Communication Planetary Envir observations
	• Increase in technical performance of spacecraft by on-orbit assembly & checkout in LEO of multi-shuttle flight systems	Envir observations

15112793-112A

The accommodations necessary to meet mission requirements for the initial phase of the Space Station includes a basic capability in LEO 28.5° inclination to house mission equipment, and provide resources - crew habitat, power, and station support systems for the early year missions.

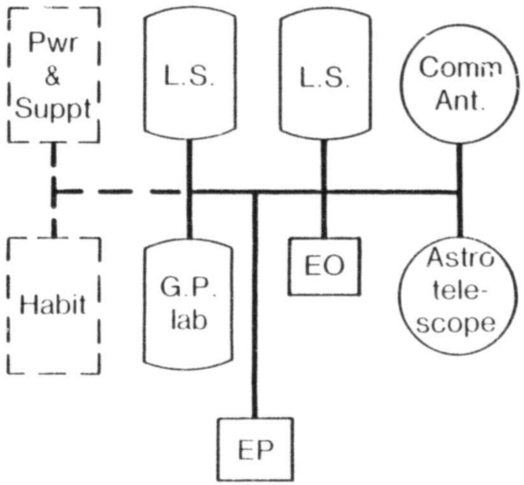
Summation of free-flyers operating in a wide range of orbits shows a need to accommodate servicing capabilities and resources for about 4 free-flyers. These free-flyers will be added to those existing in orbit in 1990, which if so designed, could also be accommodated by Space Station servicing, e.g., Leasecraft.

An OTV basing capability is required to coincide with OTV operational capability, to service and launch approximately 2 to 3 DoD satellites per year plus 1 to 2 communication satellites and planetary missions.

SUMMARY OF MISSIONS — INITIAL REQUIREMENTS (1990/1991)

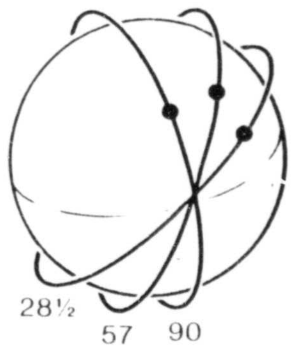
Man-operated 28½°
400-500 km

2 modules — life sciences
1 general purpose module
1 communications antenna exp
1 astro telescope
1 env obs pallet — 4m × 10m
1 earth plan pallet — 4m × 6m
4 to 6 P/L crew
~20 kw avg
(DoD-R&D can be accommodated)



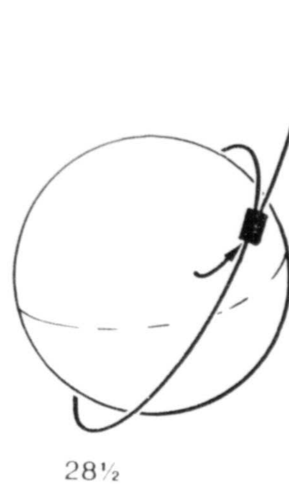
Man-tended free flyers
LEO

1 astrophys — 28½°
1 MTLS pro — 28½°
1 env obs — 57°
1 earth obs — 90°
(DoD not shown)



OTV basing

1 to 2 commun sat./yr — GEO
1 planetary sat./yr — ESC
1 earth obs — HEO
2 to 3 nat'l sec sat./yr



15112793-35A

The accommodations for the mission equipment required for the initial phase will require expansion in all areas of operation to accommodate an expanded set of missions.

The Man-Operated Function missions are augmented by increased Life Sciences research, Environmental Observations and addition of major Earth and Planetary mission equipment. Mission requirements in Astrophysics increase to accommodate additional telescopes. Communication and Technology Development are expected to continue from the initial phase, requiring capability to assemble and operate much larger elements.

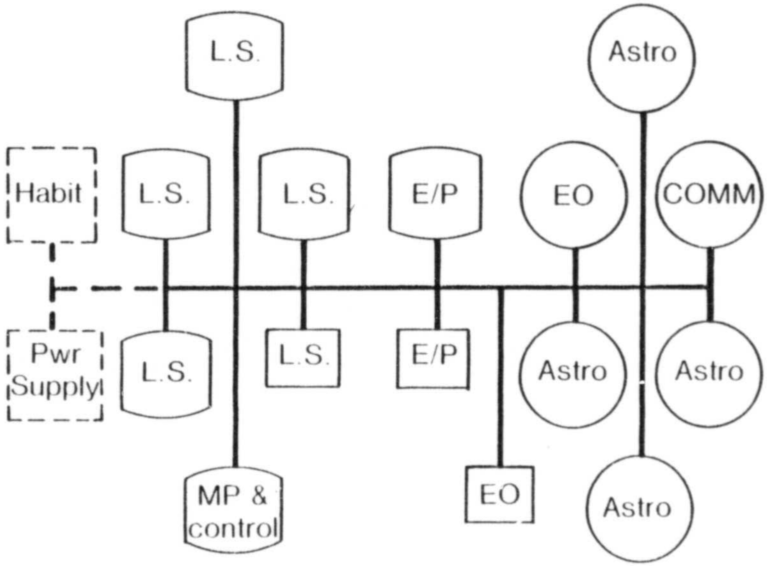
The quantity of free-flyers increases to 1 to 2 spacecraft in each orbit inclination, potentially using LEO platforms where warranted to group sensors and share services.

The OTV Basing Function grows to meet launch and service requirements for 8 DoD satellites per year, 12 to 20 communication satellites to GEO each year, along with continued Planetary missions and the addition of Environmental Observation satellites to be placed at GEO.

SUMMARY OF MISSIONS — FINAL REQUIREMENTS (2000)

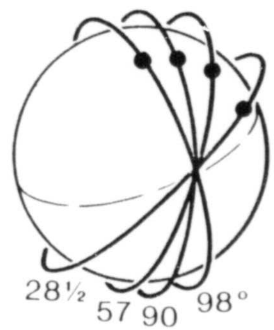
Man-operated 28½°
400-500 km

4 life science modules
1 earth/plan module
1 MP & P/L controls module
1 commun anten
1-4 astro telescopes
1 env obs antenna
1 env obs pallet — 4m × 6m
1 earth plan pallet — 4m × 20m
1 life science pallet
8 to 10 P/L crew
~ 40 kw avg
(DoD-R&D can be accommodated)



Man-tended free flyers
LEO

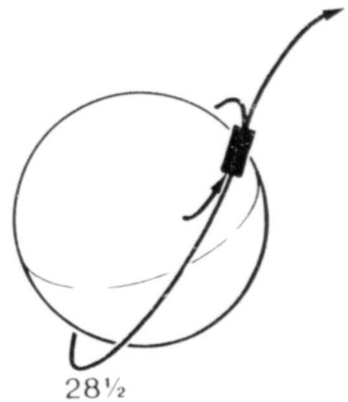
1–2 astrophys 28½°
1 mtl proc 28½°
1–2 env obs 57°
1 earth obs 90°
2 env obs 98°
(DoD not shown)



OTV basing

12 to 20 commun sat./yr — GEO
1 weather sat. (set) — GEO
1 planetary sat./yr — ESC
1 earth obs — HEO
9 nat'l sec sat./yr

ORIGINAL PAGE IS
OF POOR QUALITY



15112793-36A

MAJOR STUDY CONCLUSIONS
(continued)

A man-operated OTV base can provide economic benefits approaching $800M per year

PAGE 24 INTENTIONALLY BLANK

15112793-203

PRECEDING PAGE BLANK NOT FILMED

Estimates of the costs to deliver 150,000 pounds of payload annually to geosynchronous orbit with a space-based OTV are compared with costs of potential competitors. Space-based OTV has a significant cost advantage, due primarily to its reusability and a reduction in Shuttle costs from space-basing of the upper stage. Propellant for the higher-performance space-based vehicle is recovered from the Shuttle External Tank or delivered to LEO via dedicated ET "tanker", at an estimated cost of $250/lb. The STS portion of space-based OTV cost is based on an assumed Shuttle load factor of .225 for a typical 10,000-pound OTV payload; this cost could be reduced if payloads are optimized for Shuttle pricing policy. Hardware and launch services for space-based OTV include $1M hardware ($60M unit cost ÷ 60 flights per vehicle), $0.75M transportation (1/2 Shuttle flight for delivery of OTV to LEO), and $15M operations and refurbishment per flight. Shuttle-based and space-based reusable OTV's both utilize aerobrake-return concept.

DIRECT OPERATIONAL COST COMPARISON
Transportation to GEO

Transportation System	Cost per Flight (1984 M$)				Total Annual Cost*
	Hardware & Launch Services	STS	Propellant Delivery	Total	
Delta	30	0	0	30	4,020
Commercial Atlas/Centaur	45	0	0	45	3,245
Commercial Atlas II/Centaur	75	0	0	75	2,010
Shuttle/PAM-D	6	17	0	23	3,600
Shuttle/IUS	75	83	0	158	5,925
Shuttle/Centaur	34	83	0	117	1,570
Shuttle-based reusable OTV	13	83	0	96	2,010
Space-based reusable OTV	17	25	8	50	755

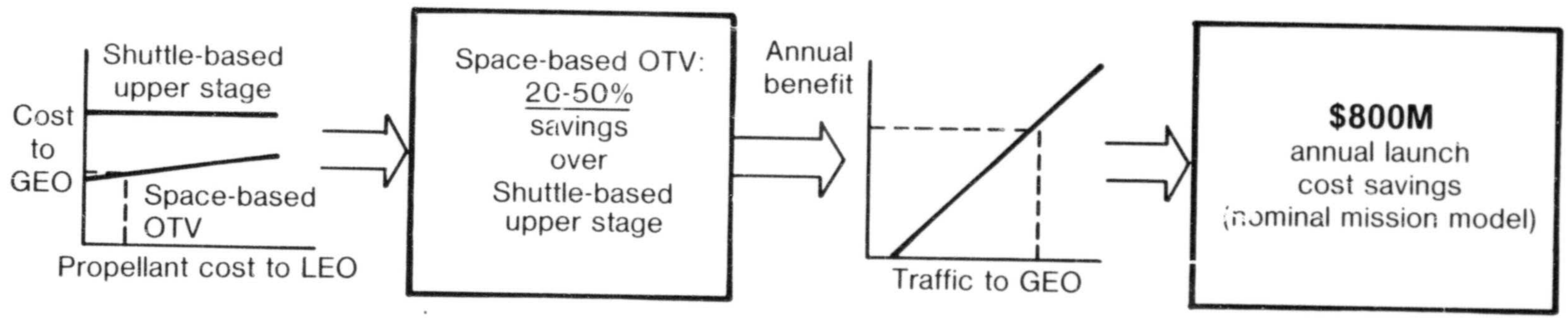
*Based on 150,000 lb/year to GEO

Likely competitor	$1,570M
Space-based OTV	755M
Direct economic benefit	815M

15112793-43

Flow-chart provides overview of a space transportation scenario which may be a key economic justification for the establishment of a Space Station. Permanent basing of a re-usable Orbital Transfer Vehicle (OTV) at a Space Station offers a potential $800 Million reduction in the annual cost of delivering payloads to Geosynchronous orbit, based on a comparison with the SBOTV's closest competitor.

SPACE STATION ECONOMIC BENEFITS
Efficiency in Space Transportation



15112793-204

MAJOR STUDY CONCLUSIONS
(continued)

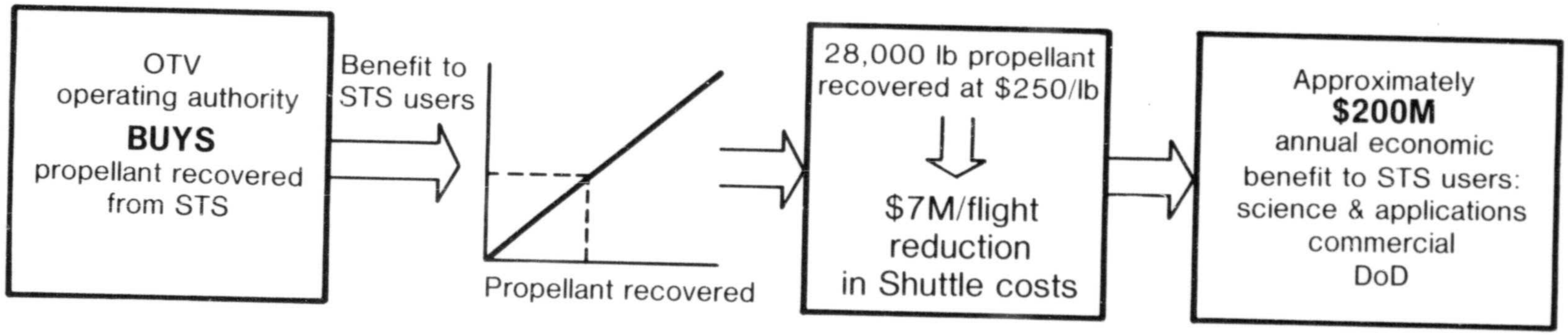
A man-operated OTV base can reduce the cost of shuttle flights to all users of the space transportation system by approximately $7M per flight

PRECEDING PAGE BLANK NOT FILMED

PAGE 30 INTENTIONALLY BLANK

An additional benefit can be realized if propellant is recovered from the Shuttle's external fuel tank; NASA could sell this propellant to OTV users (perhaps via an "OTV Operating Authority") and generate revenue to help defray Shuttle operating costs. Recovery of 28,000 lb of propellant per flight, and sale of this fuel to OTV users at $250/lb, offers a potential $7 Million reduction in the Shuttle cost-per-flight, a benefit to all users of the Space Transportation System. Total annual economic benefit from the SBOTV could approach $1 Billion, not counting the benefits of satellite checkout and servicing.

SPACE STATION ECONOMIC BENEFITS
Reduced Cost to STS Users



15112793-206

MAJOR STUDY CONCLUSIONS
(continued)

Economic benefits quantified to date exceed $1.3 billion per year, offering rapid payback of space station investment.

Significant additional economic benefits exist & are being quantified

PRECEDING PAGE BLANK NOT FILMED

PAGE 34 INTENTIONALLY BLANK

Man-Operated Function

- Permanent basing of Spacelab-type module at LEO Space Station eliminates need for Shuttle launch of Spacelab. Launch and LEO integration of replacement experiments and supplies should cost only about one-third of typical Shuttle-Spacelab mission, due primarily to reduced cargo bay use and Shuttle time-on-orbit. Savings per typical one-week equivalent Spacelab mission are conservatively estimated at $50 million.
- Reduction of time required for commercialization of applications research, particularly in materials processing in space, should result from continuous laboratory operations. Economic benefits to be determined.
- Technology development and life science advancements should yield as yet unquantified economic returns.

Servicing of LEO Free-Flyers

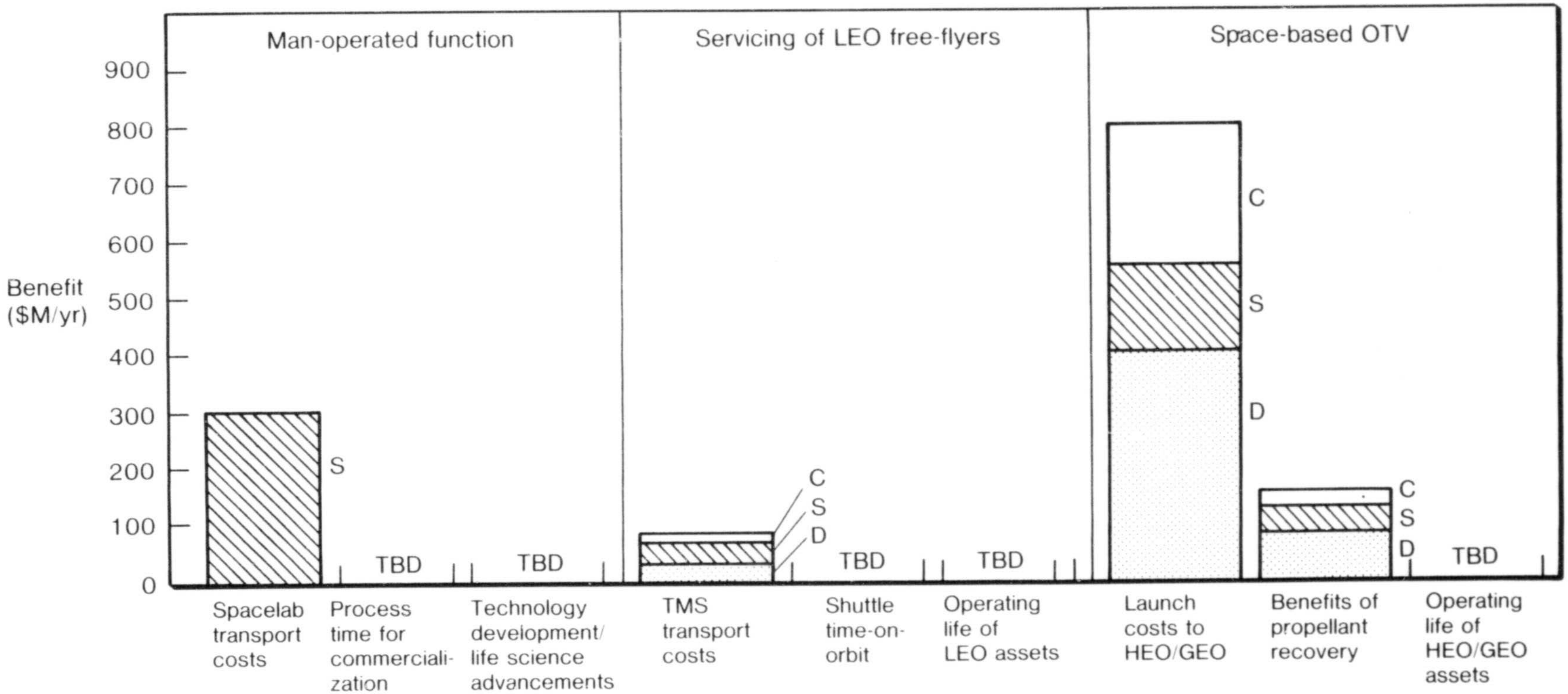
- LEO-basing of TMS will save a minimum of $5 million in Shuttle transportation costs per TMS mission. Hydrazine propellant for TMS is assumed to cost $1500/lb for delivery to LEO.
- Reduction of Shuttle time-on-orbit will result from space-basing of servicing operations.
- Extension of operating life of LEO assets could provide annual benefits of tens of millions of dollars.

Space-Based OTV

- Greatest economic benefit of Space Station appears to be reduction in launch costs to high orbits with a reusable space-based OTV. SB OTV operating costs are estimated to be 20-50% lower than Shuttle-Centaur, depending on cost of propellant delivery to LEO. Detailed analysis of OTV costs is presented in costs and programmatics section.
- Sale of propellant recovered from ET during standard Shuttle missions can generate additional revenue and cost-reduction opportunities for all Shuttle users. Nominal estimates of 28,000 lb of propellant recovered and sold to OTV users at $250/lb yields benefit of $7 million per Shuttle Flight.
- Based on projected cost per transponder-year over $250,000, among other factors, servicing of geo-synchronous communications satellites and other high-orbital assets should provide great economic benefits, to be determined.

ECONOMIC BENEFITS SUMMARY
Preliminary Analysis

ORIGINAL PAGE IS
OF POOR QUALITY



Totals

C — Commercial = $298 M (+ TBD)/yr

S — Science & applications = $583 M (+ TBD)/yr

D — Defense = $478 M (+ TBD)/yr

Total = $1359 million annual economic benefit (+ TBD)

15112793-99

MAJOR STUDY CONCLUSIONS
(continued)

- A space station can effectively provide required military space functions & significantly enhance corresponding operational missions
- Combined NASA/DoD utilization of an initial space station provides economic & technical benefits
  Preliminary studies of operational missions indicate possible need for a separate station(s)

PAGE 38 INTENTIONALLY BLANK

PRECEDING PAGE BLANK NOT FILMED

The MSSTM derived military space functions, shown on the left of the figure, are all-inclusive and broad enough to cover support to a number of military missions. The screening criteria were applied to these functional areas to define specific mission applications as described under the heading selected concept. Six operational concepts were derived by this process, expanded and used as a basis for initial contacts with the DoD community, including potential users. In examining potential operational mission applications, it became evident that logistic support across most mission areas could benefit from a manned platform. The advantages of a LEO platform to serve as a base for a reusable space-based OTV is covered in detail in other parts of this briefing. Other logistics operations are possible, however, and an additional four concepts were developed as noted in the figure.

OPERATIONAL MISSION SCREENING

Military Space Functions	Station Application	Selected Concept
Surveillance:		
Missile	No	None
Aerodynamic	No	None
Space	Yes	• Base for remote SOI, adjunct/replacement of satellite inspector
Ocean	Yes	• Observation platform for long time constant phenomena
Ground	Yes	• Data collecton support to DMA
Communications:		
Strategic	No	None
Tactical	No	None
Navigation	No	None
Meteorology	No	None
Command & Control		
Strategic	Yes	• Backup SIOP command post for SAC — space based
Tactical	No	None
Space defense	Yes	• Base for management unmanned spacecraft countermeasures
	Yes	• Classified mission
Electronic warfare	No	None
Reconnaissance	No	None
Space logistics	Yes	• LEO node for reusable OTV operation • Platform for spares stowage & reconstitution of failed spacecraft • Service of high-cost military spacecraft in LEO • Classified missions

15112793-137A

Several facts emerge from an evaluation of generic operational mission requirements. They generally require GEO or high inclination orbits and often higher than LEO altitudes. Security and survivability requirements are key and often drivers. A basic conclusion is that dedicated, i.e., not joint with scientific/foreign users, facilities are required. Some missions require multiple positions in space and are probably free-flyers. Conflicting orbit and other requirements indicate that multiple facilities are likely.

DoD RDT&E missions are derived from operational missions and directly support their evolvement when considered as two sets - R&D and T&E, logical differences are evident. Verification T&E for operational missions either require or benefit from performance in the operational environment, in this case - orbit. On the other hand, R&D missions can usually be performed under different though comparable conditions and are candidates for a low inclination LEO orbit such as that determined for S&A and commercial missions. Furthermore, the survivability requirements become progressively lower progressing from operational to R&D. Security is less demanding also but still of concern. The conclusions are, therefore, that R&D activities are suitable for a LEO low inclination orbit, even in a joint station. Some T&E missions may be also but others will require operational missions.

Because the RDT&E missions are derived from operational missions and these are not well defined at this time, the detailed technical parameters of the RDT&E missions have not been developed at this time and do not appear in our data bank like those of science, applications and technology.

DoD INFLUENCES ON EARLY STATION REQUIREMENTS

Research & development missions
- Suitable for early joint station in LEO
- Security aspects of concern
- Survivability not an issue
- Some missions (e.g., Earth obs, commun) similar to S&A & commercial
- Helps define requirements for operational missions

Test & evaluation missions
- Verification T&E for operational missions generally require access to same orbits (high inclination/high altitude)
- Some activities may be suitable for LEO-joint station

Operational missions generally require dedicated prime facilities
- High inclination/high altitude orbits
- Security & survivability are key requirements
- Availability/responsiveness/effectiveness are of high importance
- Conflict requirements set basic mission needs
- Support/training may be providable from T&E "station"

15112793-22A

AGENDA

Study Plan/Approach

Major Study Conclusions

Commerical Applications

Evolutionary Options

PRECEDING PAGE BLANK NOT FILMED

PAGE 44 INTENTIONALLY BLANK

The Space Station potential for commercial users includes both the user of station space or services, as well as the provider of equipment and operations. The list of candidates for participation started with those firms who had participated in the NASA/corporate associates program - approximately 145 firms. This list was augmented by additional firms listed in Fortune's top 500 with industry sales in metals and non-metals, chemicals, pharmaceuticals, equipment, petroleum, foods, mining and forestry, communications, aerospace, electronics, instruments and utilities.

About 180 telephone contacts were made with key department personnel in the selected firms. Almost all of those contacted expressed an interest in receiving more information of the Space Station program. Of the approximately 150 commercial firms contacted, we estimated that fewer than one-fourth were likely candidates as Space Station users. The balance were interested in drawing upon the technology to be developed. After the brochures were sent, 32 firms responded with either the fact sheet or letter.

The categories where positive interest was shown included earth and ocean observations, material processing, and communications. Most firms found the Space Station lead time beyond their present corporate planning timetable, and could only respond in generalities. It is also apparent that their interest will increase as the program comes closer to reality.

COMMERCIAL USER CONTACTS

NASA/AIAA Corporate Associates Program Listing (145) — augmented by additional firms from Fortune Top 500

- Metals & nonmetals
- Chemicals
- Pharmaceuticals
- Equipment
- Petroleum
- Foods & forestry
- Communications
- Aerospace
- Electronics
- Instruments
- Utilities

Telephone contacts made	180
• Affirmative responses	155
• Number of brochures mailed	182
Responses	32
• No interest	15
• Low interest	4
• Moderate interest	6
• High interest	7
Categories of positive responses	
• Earth & ocean observation	2
• Materials processing	6
• Communications	1
• General	3

15112793-19

Not all firms who responded provided specifics on potential commercial missions. The defined missions cover a range from research-type such as chemical reaction effects in microgravity to MPS production and monitoring the earth's atmosphere for pollution. Johnson and Johnson indicated their well-known efforts in electrophoresis but declined to provide detailed information because of their affiliation with McDonnell Douglas. Because it is an important space mission, we continue to carry it as a positive response.

The industry responses for economic factors show that their estimated investment levels toward Space Station utilization are predominantly less than one or one-to-ten million dollars. Their estimated investment horizon for Space Station related ventures are principally in the 5-10 year range. They characterized the risk associated with such ventures as fairly great.

In regards to the potential benefit of a Space Station to their activities for reducing costs are heavy on the low side with a lot of "unknown" replies. Their estimates of the industrial value of a Space Station were mixed.

Of interest was the responses to the question, to what degree has the possible availability of a manned Space Station influenced the company's planning for the next 20 years. The answers were heavily "no influence". The second question asked how this would change after receiving our User Brochure. The indications were generally a moderate increase in influence.

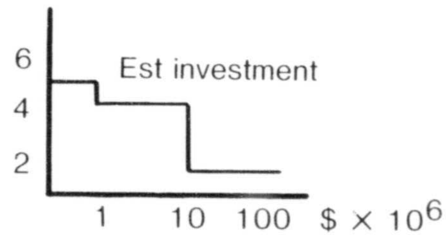
Although the sample is small, these responses were from firms who had sufficient interest to fill out and return part or all of our User Fact Sheet.

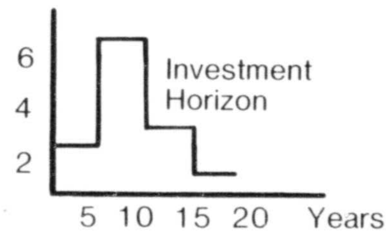
COMMERCIAL USER RESPONSES

Missions

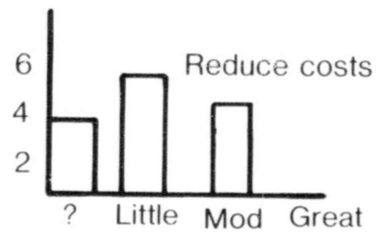
- Enzymes from fermentation
- Metal alloys (2)
- Silicon crystal growth
- Electrophoresis (details available through MDAC)
- Atmosphere sensing
- Chemical reaction effects
- Gamma ray astronomy
- Electronic equipment hardening
- Communication satellites launch/service

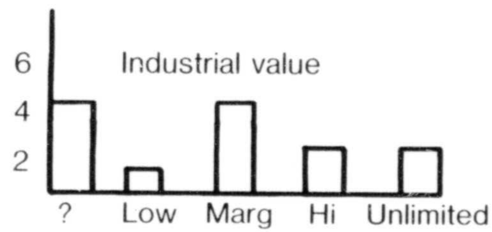
Ecomonic factors



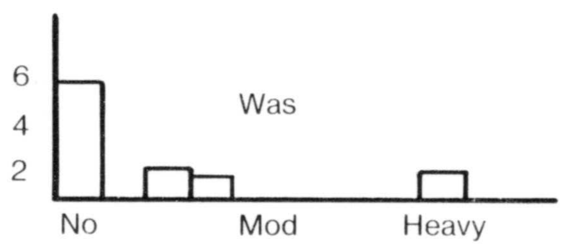


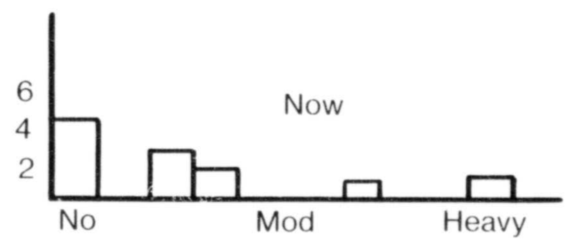
Space station potential benefit





Planning factors — (S/S influence on 20 yr planning)





15112793-20

The data received to date is very positive from the communication satellite sector. There are strong signs of interest in MPS and more limited in the earth/ocean observations sectors. We feel that although present planning is somewhat inhibited by the perceived barriers, a stronger reason for the limited interests may be due to the basic nature of businesses. For example, if one had conducted a similar study in 1885 or even 1903 about the planned uses for the new transportation system called airplanes, a similar result would have been obtained.

We feel the potential market exists and can be developed, but it will take additional time. Furthermore, once a Space Station is in being, the activities therein will generate uses and users that are not or cannot be forseen at this time.

COMMERCIAL APPLICATIONS
Preliminary Conclusions

Communication satellite placement market exists
- A space-based OTV is an economic alternative to current launch systems

Commercial communications satellite servicing a viable mission

MPS & Earth observation markets exist but need development
- Planning somewhat inhibited by perceived barriers
  - Relatively long ROI horizons
  - Space station some distance in future
  - Space operations are costly

Market potential & interests exist
- Additional time & detailed discussions required to expand beyond currently identified level
- An in-place facility will generate uses that may not surface during advanced appraisals

Special incentives may be required to induce commercial firms to increase research investments

15112793-21A

AGENDA

Study Plan/Approach

Major Study Conclusions

Commerical Applications

Evolutionary Options

PRECEDING PAGE BLANK NOT FILMED

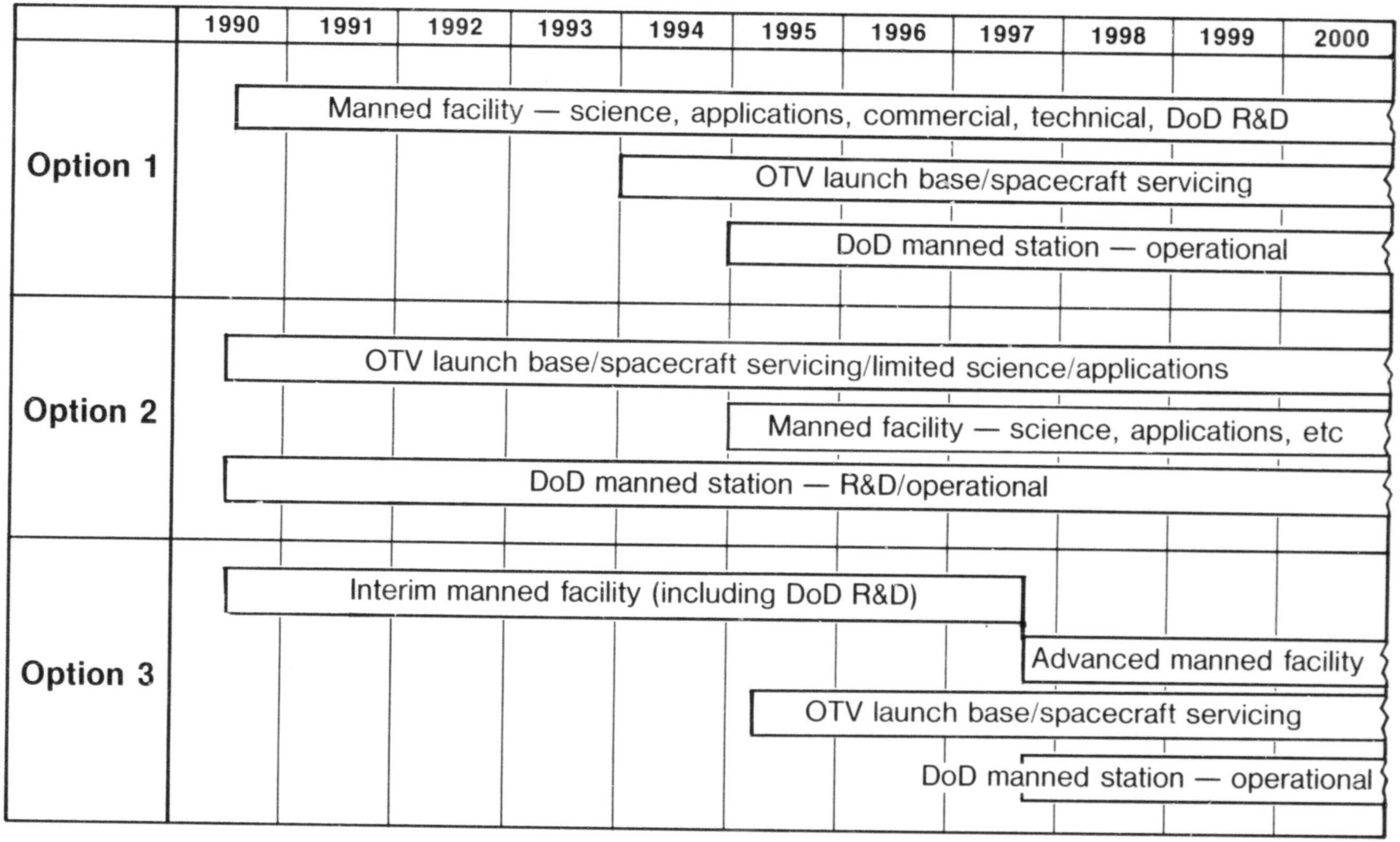
PAGE 52 INTENTIONALLY BLANK

15112793-212

Three program evolutionary options have been defined for further investigation during the second phase of this study. Each of these options, as characterized on the facing page, will be evaluated considering economic, performance, programmatic, and political implications. As a final step, a preferred option will be identified and substantiated.

GENERAL DYNAMICS
Convair Division

PRELIMINARY SPACE STATION PROGRAM
Evolutionary Options



15112793-213